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ORGANIC COMPOUNDS IN THE ENVIRONMENT

Occurrence of Ciprofloxacin, Enrofloxacin, and Florfenicol in Animal Wastewater and Water Resources

Ruicheng Wei,* Feng Ge, Ming Chen, and Ran Wang*

Antimicrobial agent residues are becoming an intractable environmental problem in soil, surface, and underground water. To obtain a broad profile of residues in animal wastewater and surface water, 24 animal wastewater, 8 animal farm effluent, 18 river water, and 8 pond water samples taken in Jiangsu in eastern China were monitored for enrofloxacin, ciprofloxacin, and florfenicol using solid phase extraction and high performance liquid chromatography/electrospray ionization–tandem mass spectrometry (HPLC/ESI–MS/MS) techniques. The results revealed that two antibacterials were detected simultaneously in 49.1% of samples, followed by three antibacterials (22.6%) and one antibacterial (22.6%). Up to 3.35, 5.93, and 2.10 μg L^{-1} for ciprofloxacin, 1.09, 4.24, and 0.50 μg L^{-1} for enrofloxacin, and 0.95, 2.40, and 2.84 μg L^{-1} for florfenicol were detected in animal farm-effluent, river, and pond water, respectively. The maximum concentrations of ciprofloxacin and enrofloxacin in animal wastewaters were 7.49 and 8.77 μg L^{-1}, respectively. Furthermore, residue levels of ciprofloxacin and florfenicol showed at least two statistical differences between any two sampling areas or two animal farms. Enrofloxacin showed no statistical difference among the sampling areas and the animal farms.

Veterinary antibacterials have been administered on a large scale as feed additives and therapeutic drugs in agricultural practice for several decades to prevent and treat bacteria-borne diseases and to improve growth rates (Kümmerer, 2009a,b). Studies have shown that as much as ~30 to 96% of the administered drugs are excreted by the medicated animals as the parent compounds and their metabolites (Alcock et al., 1999; Tolls, 2001; Lamshöft et al., 2007; Sukul et al., 2009). When the excretion is applied to agricultural fields, the antibacterials and their metabolites may interact with different soil constituents, may enter the food chain by plant uptake (Boxall et al., 2006), may leach into groundwater via leaching, or may occur in surface water via runoff and drain flow (Boxall et al., 2002; Thiele-Bruhn, 2003; Sukul and Spiteller, 2006). They may also affect the structural and functional microbial diversity in the environment and promote the occurrence and spread of antibacterial resistant bacteria, eventually posing a potential threat to human health (Isidori et al., 2005; Kümmerer, 2009a,b; Servais and Passerat, 2009; Gibson et al., 2010; Figueira et al., 2011). Numerous studies have reported the occurrence of antibacterials in animal dung (Zhao et al., 2010), soil (Kinney et al., 2006; Blackwell et al., 2007; Martínez-Carballo et al., 2007; Tamtam et al., 2011), wastewater (Duong et al., 2008; Loganathan et al., 2009; Gros et al., 2010), river water (Xu et al., 2007; Tamtam et al., 2008; Yang et al., 2010; García-Galán et al., 2011), and groundwater (Sarmah et al., 2006).

To mitigate the environmental and health risks of antibacterials, the application of antibacterials to prevent diseases or as growth promoters in animal feeds is now strictly regulated in numerous countries and has been completely prohibited in the European Union (EU) since 2006 (Boscher et al., 2010) and the United States (Food and Drug Administration, FDA, 2003). But such usage continues in other countries, including China. China is the largest producer of pig and poultry in the world, and the annual usage of antibacterials in China has been estimated to be >25,000 tons (Xu et al., 2007), 12.5 to 25% of the annual global consumption. Large quantities of manure and slurry containing various antibacterials are produced that are collected and stored in manure pits

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*Corresponding author (wangran@jaas.ac.cn; rcwei79@jaas.ac.cn).

5585 Guilford Rd., Madison, WI 53711 USA

R.C. Wei, M. Chen, and R. Wang, Jiangsu Provincial Key Lab. of Animal-Derived Food Safety; Key Open Lab. of Edible Agricultural Products Safe Monitoring and Control, Ministry of Agriculture, Nanjing, 210014,China; F. Ge, Nanjing Institute of Environmental Science, Ministry of Environmental Protection, Nanjing 210042, China. Assigned to Associate Editor Kang Xia.

Abbreviations: CPFX, ciprofloxacin; EDTA, ethylenediamine tetraacetate; ERFX, enrofloxacin; ESI, electrospray ionization; FF, florfenicol; FQ, fluoroquinolone; HPLC, high performance liquid chromatography: K-W, Kruskal–Wallis; MQL, method quantification limit; MS, mass spectrometry; RSD, relative standard deviation.